Journal of PHYSIOTHERAPY

VOLUME 58 • NO 1 • 2012

Official Journal of the Australian Physiotherapy Association

Editorial

Research

Appraisal

AUSTRALIAN PHYSIOTHERAPY ASSOCIATION

Half of the adults who present to hospital with stroke develop at least one contracture within six months: an observational study

Li Khim Kwah[1], Lisa A Harvey[2], Joanna HL Diong[1] and Robert D Herbert[1]

[1]*The George Institute for Global Health,* [2]*Rehabilitation Studies Unit, Sydney School of Medicine*
The University of Sydney, Australia

Questions: What is the incidence of contractures six months after stroke? Can factors measured within four weeks of stroke predict the development of elbow, wrist, and ankle contractures six months later? **Design**: Prospective cohort study. **Participants**: Consecutive sample of 200 adults with stroke admitted to a Sydney hospital. **Outcome measures**: Loss of range of motion in major joints of the body was measured using a 4-point ordinal contracture scale. In addition, elbow extension, wrist extension, and ankle dorsiflexion range of motion were measured using torque-controlled procedures. Potential predictors of contracture were age, pre-morbid function, severity of stroke, muscle strength, spasticity, motor function, and pain. Measurements were obtained within four weeks of stroke and at six months after stroke. **Results**: 52% of participants developed at least one contracture. Incidence of contracture varied across joints from 12% to 28%; shoulders and hips were most commonly affected. Muscle strength was a significant predictor of elbow, wrist, and ankle joint range. Prediction models explained only 6% to 20% of variance in elbow, wrist, and ankle joint range. **Conclusion**: About half of all patients with stroke develop at least one contracture within six months of stroke. Incidence of contractures across all joints ranged from 12% to 28%. Muscle strength is a significant predictor of elbow, wrist, and ankle contractures but cannot be used to accurately predict contractures in these joints. **[Kwah LK, Harvey LA, Diong JHL, Herbert RD (2012) Half of the adults who present to hospital with stroke develop at least one contracture within six months: an observational study. *Journal of Physiotherapy* 41–47]**

Key words: Contracture, Stroke, Incidence, Prognosis

Introduction

Contractures, or loss of passive joint range of motion (Dudek and Trudel 2008), are common after stroke (Ada and Canning 1990). Contractures can limit performance of functional activities such as standing, walking, dressing, and grooming (Ada and Canning 1990, Dudek and Trudel 2008, Fergusson et al 2007). They are also associated with pain, pressure ulcers, falls, and other complications that increase dependence (Wagner and Clevenger 2010). Yet there are few quantitative data on the proportion of patients who develop contractures, the location of contractures, or the characteristics of patients most susceptible to developing contractures after stroke.

Two prospective cohort studies have estimated the incidence of contractures one year after stroke. One reported an incidence of 23% (Pinedo and de la Villa 2001) whereas the other reported an incidence of 60% (Sackley et al 2008). One possible explanation for why these estimates differ may be that one cohort consisted of patients recruited from a rehabilitation hospital (Pinedo and de la Villa 2001) and the other consisted of patients with a severe disabling stroke identified from a register (Sackley et al 2008). To our knowledge, no studies have documented the incidence of contractures in the broader population of patients who present to hospital with stroke. Such data are needed to quantify the magnitude of the problem of contractures after stroke.

It would be useful to identify patients who are most susceptible to developing contractures. If that were possible, clinicians and researchers could target high risk patients for intensive therapy and include high risk patients in future trials of interventions designed to prevent contractures. Three longitudinal studies have reported that the development of elbow and wrist contractures could be predicted by baseline measures of weakness, spasticity and upper limb function (Ada et al 2006, Malhotra et al 2011, Pandyan et al 2003). However these studies were small ($n \leq 30$ in all three studies), did not examine multivariate predictors (Malhotra et al 2011, Pandyan et al 2003), and considered few potential predictors (Ada et al 2006, Malhotra et al 2011, Pandyan et al 2003).

The research questions for this study were:

1. What is the incidence of contractures six months after stroke?
2. Can factors measured soon after stroke predict the development of elbow, wrist, and ankle contractures?

What is already known on this topic: Contractures are common after stroke. They can limit functional performance and cause complications such as pain, pressure ulcers, and falls.

What this study adds: Within six months after stroke, about half of all patients develop a contracture. Muscle strength is a significant predictor of elbow, wrist, and ankle contractures but cannot be used to accurately predict contractures in these joints. Simple clinical measures do not accurately predict who will develop a contracture.

Method

Design

A prospective inception cohort study was conducted. Consecutive patients admitted to the accident and emergency department of St George Hospital (from January 2009 to January 2010) with a diagnosis of stroke or transient ischemic attack were screened. St George Hospital is a large teaching hospital that serves residents of southern Sydney, Australia, and admits more than 500 patients a year with stroke and transient ischaemic attacks (SESIAHS 2010). Participants were followed up six months after stroke.

Participants

Patients were eligible for inclusion if they were over 18 years old, had a medically documented stroke (WHO 1988), were able to respond to basic commands, and understood English. Patients who received recombinant tissue plasminogen activator were included if they had persisting neurological symptoms 24 hours after receiving treatment. Patients with subarachnoid haemorrhages were included only if they had neurological symptoms consistent with the WHO definition of stroke (WHO 1988). Consent was sought from patients or, where patients were unable to consent, from guardians. All patients received standard medical and allied health care. Although no attempt at standardisation was made, care was generally administered in a way that was broadly consistent with the recommendation of the National Stroke Foundation guidelines (NSF 2010).

Outcome measures

Three physiotherapists collected the data. Joint range of motion was measured as soon as possible (within four weeks) and six months following stroke. All measurements were performed with the participants either in supine or sitting. The following procedures were used.

Contracture scale: A 4-point ordinal scale was used to measure joint range in all major upper and lower limb joints of the body including the shoulders, elbows, forearms, wrists, fingers, thumbs, hips, knees, and ankles. Therapists passively moved each joint through the available range of motion, assessing most planes of movement at each joint. As it was necessary to measure a large number of joint ranges in an acceptable period of time, a goniometer was not used. Range was scored as 0 ('no loss in range of motion'), 1 ('loss of up to 1/3 range of motion'), 2 ('loss of 1/3 to 2/3 range of motion'), or 3 ('loss of greater than 2/3 range of motion'). Therapists were instructed to categorise the loss of joint range in the patient with respect to joint range expected in a person of similar age without contractures. Provided the contralateral side was not also impaired, the contralateral limb was used as a reference. Reliability was tested in a separate sample of 27 community-dwelling patients with multiple sclerosis, spinal cord injury, or stroke. The inter-rater reliability was acceptable (Kendall's tau statistic = 0.62, bootstrapped 95% CI 0.49 to 0.74). A participant was considered to have developed an incident contracture in a particular joint if there was an increase of one or more points on the contracture scale between baseline and final measures.

Torque-controlled measures: Torque-controlled measures of range of motion were also obtained. These measures were more time consuming to collect, so they were obtained only for elbow extension, wrist extension, and ankle dorsiflexion. The procedures have been described in detail elsewhere (Harvey et al 1994, Moseley and Adams 1991, Moseley et al 2008). The ankle dorsiflexion procedure was modified slightly from the published description of the method (Moseley and Adams 1991). A spring balance and cuff were secured over the foot. The knee was extended. Ankle dorsiflexion range was measured using a plurimeter placed on the lateral aspect of the foot and the shank. Intra-rater reliability of the elbow extension procedure (ICC = 0.98, 95% CI 0.93 to 1.00) (Moseley et al 2008) and the wrist extension procedure (ICC = 0.71, 95% CI 0.38 to 1.00) (Harvey et al 1994) has been demonstrated. We tested the inter-rater reliability for the modified ankle dorsiflexion procedure on a separate sample of 33 community-dwelling patients with multiple sclerosis, spinal cord injury, or stroke. Reliability was good (ICC = 0.86, 95% CI 0.81 to 0.92). A participant was considered to have developed a contracture if there was a minimum loss of 10 degrees between baseline and final measurements.

The force applied during joint range measurements was determined by what the therapists felt was end-range of motion at a joint or by the force tolerated by the patient. In the torque-controlled measurements, the force was quantified with the use of a spring balance and the same force was ensured for both baseline and final measures in each patient.

Candidate predictors

Candidate predictors were measured within four weeks of stroke. A total of nine candidate predictors were considered. Pre-morbid function was measured using the Barthel Index (Collin et al 1988, Kasner 2006). Severity of stroke was measured using the National Institutes of Health Stroke Scale (NIHSS) (Brott et al 1989, Kasner 2006). Muscle strength of elbow, wrist, and ankle flexors and extensors was assessed using the Manual Muscle Testing scale (Hislop and Montgomery 2007, Kendall et al 1993). Spasticity of elbow and wrist flexors and ankle plantarflexors was measured using the Tardieu Scale. Spasticity was considered to be present if a catch or clonus was observed during the fast-velocity component of the Tardieu scale (Patrick and Ada 2006). Motor function of upper and lower limbs was measured using Item 4 (sitting to standing), Item 5 (walking) and Items 6–8 (upper arm function, hand movements, advanced hand activities) of the Motor Assessment Scale (Carr et al 1985). Pain at the elbow, wrist and ankle was assessed using a vertical numerical rating scale (Leung et al 2007). The reliability of these procedures had been demonstrated (Carr et al 1985, Florence et al 1992, Kasner 2006, Lannin 2004, Leung et al 2007, Mehrholz et al 2005).

Data analysis

Incidence proportions of any contracture and of contracture in each joint were calculated for the whole cohort and for the sub-cohort of patients with moderate to severe strokes (NIHSS > 5). Confidence intervals were calculated using Newcombe's method based on Wilson scores (Newcombe 1998). For bilateral strokes, the side that performed worse at baseline was chosen for analysis; if both sides were the same, one side was randomly selected.

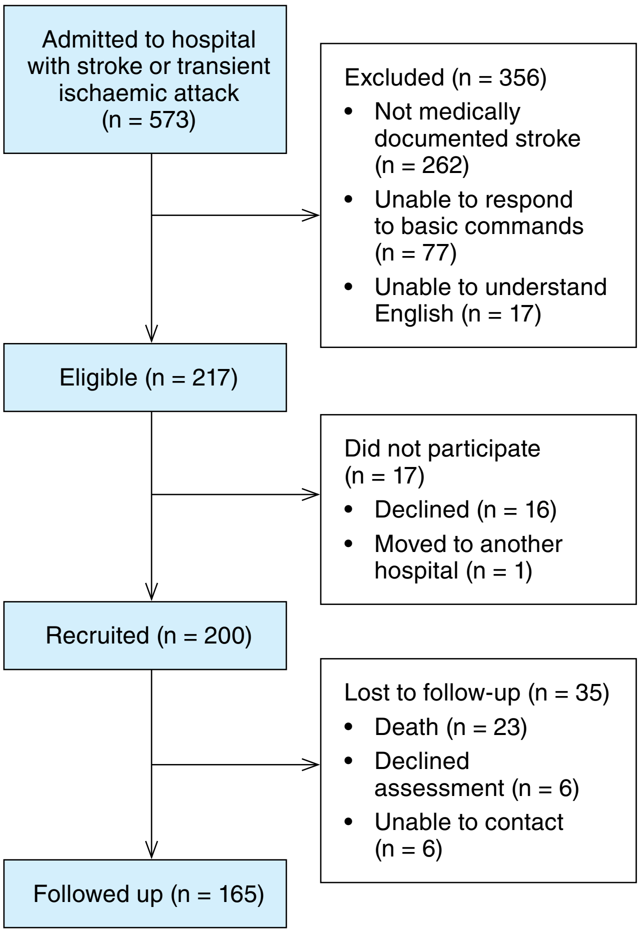

Figure 1. Flow of participants through the study.

Table 1. Characteristics of participants.

Characteristics	All participants (n = 200)	Participants available at follow-up (n = 165)
Age *(yr)*, median (IQR)	78 (65 to 84)	77 (65 to 83)
Gender, n females (%)	102 (51)	85 (52)
Thrombolysed, n (%)	19 (10)	16 (10)
Side of hemiplegia, n (%)		
right	94 (47)	75 (45)
left	89 (45)	74 (45)
both	17 (8)	16 (10)
Type of stroke, n (%)		
ischaemic	134 (67)	106 (64)
intracerebral haemorrhage	42 (21)	38 (23)
subarachnoid haemorrhage	7 (4)	8 (5)
unknown	17 (8)	13 (8)
Pre-morbid function (BI), n (%)		
≤ 95	47 (24)	34 (21)
96 to 100	153 (76)	131 (79)
Severity of stroke (NIHSS)[a], n (%)		
mild (0 to 5)	107 (54)	94 (57)
moderate (6 to 13)	59 (30)	49 (30)
severe (14 to 42)	33 (16)	22 (13)

BI = Barthel Index, IQR = Inter-quartile range, NIHSS = National Institutes of Health Stroke Scale, [a] = NIHSS had one missing datum

Regression analyses were conducted with the aim of identifying people who were most susceptible to developing contractures. As there were very few missing data, only patients with complete data sets of candidate predictors and joint range were considered in the statistical analysis. The dependent variables for these analyses were the torque-controlled measures of elbow extension, wrist extension, and ankle dorsiflexion range of motion. Univariate linear regressions were carried out to determine the relationship between predictors (measured within four weeks of stroke) and outcomes (measured at six months after stroke). All predictors except spasticity were treated as continuous variables (Royston et al 2009). Spasticity was treated as a dichotomous variable. All predictors were entered into the initial model for multivariate analysis. The exception was predictors that were highly correlated ($r > 0.6$), in which case only the predictor that was easier to obtain in clinical practice was entered into the model. A bootstrap variable selection procedure was used that involved drawing 1000 samples from the original sample and carrying out backwards stepwise regression (with p value set at 0.2 to remove) in each bootstrap sample (Austin and Tu 2004). Predictors that were retained in 80% of the bootstrap samples were selected for the final model. Regression coefficients were zero-corrected to reduce bias (Austin 2008). Variable selection by bootstrapping has been shown to improve estimates of regression coefficients and their confidence intervals compared with conventional backwards stepwise selection of predictors (Austin 2008). Performance of the final models was evaluated with adjusted r^2 values.

Results

Flow of participants through the study

The flow of participants through the study is shown in Figure 1. Characteristics of participants are shown in Table 1. Baseline measurements were taken at a median of 6 days (IQR 3 to 11) after stroke. One hundred and sixty-five participants were followed up at a median of 6.1 months (IQR 5.9 to 6.4) after stroke.

Missing data

Follow-up data were not available from 35 participants: 23 died and 12 declined to be re-assessed or could not be contacted. In addition, joint range measurements were missing for a small number of participants (1 to 3) due to fractures and pain at the joints (Table 2). The development of prediction models required complete data sets of both outcomes and candidate predictors. For the prediction

Table 2. Incidence proportion of contractures by joint, as measured with the contracture scale and with torque-controlled procedures.

	All participants		Moderate to severe strokes (NIHSS > 5)	
	n/N	% (95% CI)	n/N	% (95% CI)
Contracture scale				
shoulder	41/165	25% (18 to 32)	27/71	38% (26 to 50)
elbow and forearm	36/165	22% (15 to 28)	25/71	35% (24 to 47)
wrist and hand	22/164	13% (8 to 19)	20/70	29% (18 to 39)
hip	46/165	28% (21 to 35)	26/71	37% (25 to 48)
knee	19/165	12% (7 to 16)	13/71	18% (9 to 28)
ankle	24/165	15% (9 to 20)	18/71	25% (15 to 36)
Torque-controlled				
elbow extension	29/163	18% (12 to 24)	19/69	28% (17 to 38)
wrist extension	29/162	18% (12 to 24)	17/68	25% (14 to 36)
ankle dorsiflexion	19/164	12% (7 to 17)	14/70	20% (10 to 30)

n = number of participants who developed contracture, N = total number of participants

analysis, data sets were incomplete for 10 participants for elbow extension and ankle dorsiflexion and for 11 participants for wrist extension due to fractures, pain, poor compliance or inability to follow complex commands.

Incidence of contractures after stroke

Incidence proportions of contractures classified by joints are presented in Table 2. Incidence proportions of participants with at least one contracture are presented in Appendix 1 of the eAddenda. In addition, we explored the incidence proportion of contractures defined in various ways in Appendices 1 to 3 of the eAddenda.

Contracture scale: Of 165 participants, 85 had an increase in contracture scale score at one or more joints at six months. Thus 52% (95% CI 44 to 59) developed at least one contracture. The incidence of contractures varied across joints from 12% to 28%. Shoulder and hip joints were most commonly affected. In participants with moderate to severe strokes (NIHSS > 5), the incidence of contractures was higher. Of 71 participants with moderate to severe strokes, 47 (66%, 95% CI 55 to 76) developed at least one contracture. The incidence of contractures varied across joints from 18% to 38% (Table 2).

Torque-controlled measures: Of 164 participants, 60 (37%; 95% CI 30 to 44) developed at least one contracture in the elbow, wrist, or ankle after stroke, according to the torque-controlled measures. The incidence of contractures was 18% (elbow extension), 18% (wrist extension), and 12% (ankle dorsiflexion) at six months after stroke. In patients with moderate to severe strokes (NIHSS > 5) these estimates increased to 28% (elbow extension), 25% (wrist extension), and 20% (ankle dorsiflexion). In participants with moderate to severe strokes, 35 of 70 participants (50%; 95% CI 39 to 61) developed at least one contracture (Table 2).

Prediction of elbow, wrist and ankle contractures after stroke

Univariate analysis: Severity of stroke, muscle strength, and motor function were significantly associated ($p < 0.05$) with range of motion at six months (Table 3). However, only 1% to 17% of the variation in range of motion was explained by these predictors.

Multivariate analysis: As several of the candidate predictors were highly correlated with each other, only five of the candidate predictors (age, pre-morbid function, strength, spasticity, and pain) were entered into the multivariate analysis (Table 4). Muscle strength was the only predictor selected in more than 80% of bootstrap samples. Even when all five predictors were forced into the model, they only explained 6% to 20% of variation in contracture development (adjusted r^2 of full model for elbow extension = 0.19, wrist extension = 0.20, ankle dorsiflexion = 0.06).

Discussion

This study provides the first robust estimates of the incidence of contractures in a representative sample of patients presenting to hospital with stroke. The data indicate that contractures are common; half the cohort (52%) developed at least one contracture. Contractures are most common at the shoulder and hip, and more common in those with moderate to severe strokes (NIHSS > 5). The data do not provide any further guidance on which patients are most susceptible to contractures. It is widely believed that factors such as strength, pain, spasticity, and severity of stroke help predict contractures yet in our models none of these factors explain more than 20% of variation in range of motion at six months.

Few cohort studies have investigated the incidence of contractures after stroke (Fergusson et al 2007). Current estimates of the incidence proportion of contractures vary from 23% to 60% in the year after stroke (Pinedo and de la Villa 2001, Sackley et al 2008). Direct comparisons of our estimates to these studies are difficult due to the difference

Table 3. Univariate associations between candidate predictors and change in elbow extension, wrist extension and ankle dorsiflexion joint range.

Candidate predictors	Elbow extension		Wrist extension		Ankle dorsiflexion	
	Coefficients (95% CI)	r^2	Coefficients (95% CI)	r^2	Coefficients (95% CI)	r^2
Age	–0.08 (–0.23 to 0.07)	0.01	–0.02 (–0.20 to 0.16)	0.00	–0.005 (–0.12 to 0.11)	0.00
Pre-morbid function	0.19 (0.03 to 0.36)*	0.03	0.20 (–0.02 to 0.41)	0.02	0.06 (–0.06 to 0.19)	0.01
Severity of stroke	–0.66 (–1.01 to –0.31)**	0.08	–0.96 (–1.37 to –0.56)**	0.12	–0.36 (–0.63 to –0.08)*	0.04
Muscle strength–flexors	2.78 (1.80 to 3.77)**	0.17	3.34 (2.17 to 4.52)**	0.17	1.48 (0.66 to 2.30)**	0.08
Muscle strength–extensors	2.85 (1.86 to 3.83)**	0.17	3.28 (2.12 to 4.44)**	0.17	1.58 (0.74 to 2.43)**	0.08
Motor function–combined upper arm	2.25 (1.45 to 3.06)**	0.17	2.67 (1.70 to 3.63)**	0.16	–	–
Motor function–sitting to standing	–	–	–	–	0.76 (0.09 to 1.43)*	0.03
Motor function–walking	–	–	–	–	0.48 (–0.28 to 1.23)	0.01
Spasticity	–4.00 (–9.59 to 1.58)	0.01	–7.53 (–17.29 to 2.24)	0.01	–6.14 (–10.79 to –1.49)*	0.04
Pain	0.54 (–1.62 to 2.70)	0.00	1.15 (–2.54 to 4.84)	0.00	–1.37 (–2.52 to –0.22)*	0.03

*$p < 0.05$, **$p < 0.01$

Table 4. Multivariate associations between candidate predictors and change in elbow extension, wrist extension and ankle dorsiflexion joint range.

Candidate predictors	Elbow extension		Wrist extension		Ankle dorsiflexion	
	%	Coefficient (95% CI)	%	Coefficient (95% CI)	%	Coefficients (95% CI)
Age	36	–	31	–	34	–
Pre-morbid function	51	–	71	–	33	–
Muscle strength	100	3.34 (1.67 to 5.67)	100	3.50 (1.65 to 5.36)	81	1.07 (0 to 2.24)
Spasticity	51	–	25	–	42	–
Pain	75	–	62	–	55	–
Constant	100	–23.85 (–80.94 to 6.48)	100	–33.95 (–89.09 to 2.45)	100	–4.10 (–24.68 to 14.13)

% = % retained in bootstrap samples

in characteristics of cohorts and lack of detailed information regarding measurement and definitions of contractures. However, our estimates broadly align with those of earlier studies. Our estimates may have been higher if we had measured incidence of contractures at one year rather than six months after stroke.

It is not clear why we were not better able to predict those susceptible to contractures. The predictors were chosen because they are believed to be associated with the development of contractures. Interestingly, even spasticity, which is widely believed to predict contractures (Ada et al 2006), was not a good predictor (it was selected in only 25% to 48% of bootstrap samples). This was despite the high incidence of spasticity at baseline (25 elbows, 11 wrists, 21 ankles). Pain was arguably a better predictor than spasticity (selected in a greater number of bootstrap samples than spasticity) even though few joints were painful (4 elbows, 2 wrists, 6 ankles). It is also possible that our failure to predict contractures could have been due to errors associated with the measurement of either predictors or outcomes (contractures). However, the reliability of measurement of all predictors used in the study had been demonstrated and the reliability of measures of joint range used in the prediction analyses was high (ICC > 0.8).

Our study had some limitations. First, there is little consensus in the literature regarding definitions of contracture (Fergusson et al 2007). Our definitions of contracture were chosen so that they could be applied easily to many joints, but they may not concur with other definitions of contracture or have functional implications. Choosing a definition of contracture that reflects a 'functionally significant' loss in joint range is difficult as this will vary across individuals and across joints. As some readers may wish that contracture was defined differently, we have included more information on the incidence of contractures defined in various ways in Appendices 1 to 3 of the eAddenda. Second, patients were recruited from only one site. As with any single-site study, the study sample may not be widely representative because of site idiosyncrasies. Last, a small proportion of data were missing, particularly from patients who were unable to be scored on the Motor Assessment Scale or the pain rating scale because of language deficits or impaired cognition. More viable measures of function and pain, eg, proxy measures of pain (Sackley et al 2008) or multiple imputation techniques (Sterne et al 2009), could be used to reduce the potential bias caused by missing data in future studies.

In conclusion, about half of all patients developed at least one contracture after stroke. Incidence of contractures across all joints ranged from 12% to 28% six months after stroke. A range of simple clinical measures do not accurately predict who will develop a contracture. ■

eAddenda: Appendices 1, 2, and 3 available at jop.physiotherapy.asn.au

Ethics: The local Human Research Ethics committee (South Eastern Sydney and Illawarra Area Health Service) approved this study. All participants or guardians gave written informed consent before data collection began.

Competing interests: None.

Support: The project was supported by the Physiotherapy Research Foundation, and by the Neurology Department of St George Hospital. Professor Herbert is supported by the Australian NHMRC.

Acknowledgements: The authors thank patients and family members who were part of the study. The authors also thank the assistance of Li Na Goh and Min Jiat Teng who worked as research assistants on the project.

Correspondence: Professor Rob Herbert, Musculoskeletal Division, The George Institute for Global Health, University of Sydney, Australia. Email: rherbert@georgeinstitute.org.au

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